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JC10 Rec'd PCT/PTO 07 DEC 2001

12/07/01

U.S. DEPARTMENT OF COMMERCE PATENT AND TRADEMARK OFFICE		ATTORNEY'S DOCKET NUMBER 6727/OK097
<b>TRANSMITTAL LETTER TO THE UNITED STATES DESIGNATED/ELECTED OFFICE (DO/EO/US)</b>		
INTERNATIONAL APPLICATION NO. 00/00337	INTERNATIONAL FILING DATE 07 June 2000	PRIORITY DATE CLAIMED 08 June 1999

TITLE OF INVENTION

**INFRA-RED LIGHT SOURCE**

APPLICANT(S) FOR DO/EO/US

**Lewis COLMAN**

Applicant herewith submits to the United States Designated/Elected office (DO/EO/US) the following items and other information:

1. ☒ This is a **FIRST** submission of items concerning a filing under 35 U.S.C. 371.
2. ☐ This is a **SECOND** or **SUBSEQUENT** submission of items concerning a filing under 35 U.S. C. 371.
3. ☐ This is an express request to begin national examination procedures (35 U.S.C. 371 (f)) at any time rather than delay examination until the expiration of the applicable time limit set in 35 U.S. C. 371 (b) and PCT Articles 22 and 39 (1).
4. ☒ A proper Demand for International Preliminary Examination was made by the 19th month from the earliest claimed priority date.
5. ☒ A copy of the International Application as filed (35 U.S. C. 371 (c) (2) )
  - a. ☐ is transmitted herewith (required only if not transmitted by the International Bureau).
  - b. ☒ has been transmitted by the International Bureau
  - c. ☐ is not required, as the application was filed in the United States Receiving Office (RO/US)
6. ☐ A translation of the International Application into English (35 U.S. C. 371 (c)2)).
7. ☐ Amendments to the claims of the International Application under PCT Article 19 (35 U.S.C. 371 (c)(3))
  - a. ☐ are transmitted herewith (required only if not transmitted by the International Bureau).
  - b. ☐ have been transmitted by the International Bureau.
  - c. ☐ have not been made; however, the time limit for making such amendments has NOT expired.
  - d. ☐ have not been made and will not be made.
8. ☐ A translation of the amendments to the claims under PCT Article 19 (35 U.S.C. 371 (c) (3)).
9. ☒ An (UNSIGNED) oath or declaration of the inventor(s) (35 U.S.C. 371(c)(4)).
10. ☐ A translation of the annexes to the International Preliminary Examination Report under PCT Article 36 (35 U.S.C. 371 (c)(5)).

Items 11. to 16. below concern other document(s) or information included:

11. ☐ An Information Disclosure Statement under 37 CFR 1.97 and 1.98 (with references).
12. ☐ An assignment document for recording. A **separate** cover sheet in compliance with 37 CFR 3.28 and 3.31 is included.
13. ☒ A FIRST preliminary amendment.  
☐ A SECOND or SUBSEQUENT preliminary amendment.
14. ☐ A substitute specification.
15. ☐ A change of power of attorney an/or address letter.
16. ☐ Other items or information:

**EXPRESS MAIL CERTIFICATE**  
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I hereby certify that, on the date indicated above, this paper or fee was deposited with the U.S. Postal Service & that it was addressed for delivery to the Assistant Commissioner for Trademarks, 2900 Crystal Drive, Arlington, VA 22202-3513 by "Express Mail Post Office to Addressee" service.  
*Patent*  
*DB Beck*  
Name (Print) *DB Beck* Signature *DB Beck*

U.S. APPLICATION NO. (if known sec 37 C.F.R.1.50)

INTERNATIONAL APPLICATION NO.: PCT/IL00/00337

Attorney's Docket Number  
 6727/OK097

17. [x] The following fees are submitted:

**Basic National Fee (37 CFR 1.492 (a)(1)-(5)):**

Search Report has been prepared by the EPO [X] or JPO []

\$890.00

International preliminary examination fee paid to USPTO (37 CFR 1.482)

\$710.00

No international preliminary examination fee paid to USPTO (37 CFR 4.482)  
 but international search fee paid to USPTO (37 CFR 1.445 (a) (2)...

\$740.00

Neither international preliminary examination fee (37 CFR 1.482) nor international search fee (37 CFR 1.445(a)(2)) paid to USPTO.....

\$1,040.00

International preliminary examination fee paid to USPTO (37 CFR 1.482)  
 and all claims satisfied provisions of PCT Article 33(2)-(4)....

\$100.00

ENTER APPROPRIATE BASIC FEE AMOUNT

\$890.00

Surcharge of \$130.00 for furnishing the oath or declaration later than []20 []30 months from the earliest claimed priority date (37 CFR 1.492(e)).

\$

Claims	Number Filed	Number Extra	Rate		
Total Claims	14-20	0	X \$18.00	\$00	
Independent Claims	4-3	1	X \$84.00	\$84.00	
Multiple dependent claims(s) (if applicable)			+ 280	\$	
TOTAL OF ABOVE CALCULATIONS =				\$974.00	
Reduction by 1/2 for filing by small entity, if applicable.				\$0.00	
SUBTOTAL =				\$974.00	
Processing fee of \$130.00 for furnishing the English translation later the [] 20 [] 39 months from the earliest claimed priority date (37 CFR 1.492(f)).				\$	
TOTAL NATIONAL FEE =				\$974.00	
Fee for recording the enclosed assignment (37 CFR 1.21(h)). the assignment must be accompanied by an appropriate cover sheet (37 CFR 3.28, 3.31). \$40.00 per property				\$0.00	
TOTAL FEES ENCLOSED =				\$974.00	
				Amount to be: refunded	\$
				charged	\$

a. [X] A check in the amount of \$974.00 to cover the above fees is enclosed.

b. [] Please charge my Deposit Account No.04-0100 in the amount of \$ to cover the above fees.

c. [X] The Commissioner is hereby authorized to charge any additional fees which may be required, or credit any overpayment to Deposit Account No. 04-0100. A duplicate copy of this sheet is enclosed.

**NOTE: Where an appropriate time limit under 37 CFR 1.494 or 1.495 has not been met, a petition to revive (37 CFR 1.137(a) or (b)) must be filed and granted to restore the application to pending status.**

SEND ALL CORRESPONDENCE TO:

S. Peter Ludwig  
 Darby & Darby P.C.  
 805 Third Avenue  
 New York, New York 10022-7513

SIGNATURE

NAME S. Peter Ludwig

REGISTRATION NO. 25,351

10/009845

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## EXPRESS MAIL CERTIFICATE

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PLEASE CHARGE ANY DEFICIENCY UP TO \$300.00 OR CREDIT ANY EXCESS IN THE FEES DUE WITH THIS DOCUMENT TO OUR DEPOSIT ACCOUNT NO. 04-0100

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07278

PATENT TRADEMARK OFFICE

Docket No: 6727/OK097

IN THE UNITED STATES PATENT AND TRADEMARK OFFICE

In re Application of: Lewis COLMAN

Serial No.: Not Yet Assigned

Art Unit: N/A

Filed: Concurrently herewith

Examiner: N/A

For: **INFRA-RED LIGHT SOURCE**

**MARK-UP OF AMENDED SPECIFICATION AND CLAIMS  
OF DECEMBER 7, 2001**

Hon. Commissioner of  
Patents and Trademarks  
Washington, DC 20231

December 7, 2001

Sir:

**IN THE SPECIFICATION:**CROSS REFERENCE TO RELATED APPLICATIONS

This is the U.S. national phase application based upon international application no. PCT/IL00/00337 filed June 7, 2000, and published in English on

December 14, 2000, which is a continuation in part of U.S. application serial no. 09/542,768 filed April 4, 2000. The entire disclosures of the prior applications are incorporated herein by reference.

**IN THE CLAIMS:**

8. (Amended) The method according to [any of the previous claims] claim 1, wherein said IR-active gas species is carbon dioxide.

14. (Amended) The lamp according to [any of claims 10 to 13] claim 10, wherein said IR-active gas species is carbon dioxide.

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Customer No.:



07278

PATENT TRADEMARK OFFICE

Docket No: 6727/0K097

IN THE UNITED STATES PATENT AND TRADEMARK OFFICE

In re Application of: Lewis COLMAN

Serial No.: Not Yet Assigned

Art Unit: N/A

Filed: Concurrently herewith

Examiner: N/A

For: **INFRA-RED LIGHT SOURCE**

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PRELIMINARY AMENDMENT

Name (Print) \_\_\_\_\_

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Hon. Commissioner of  
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Washington, DC 20231

December 7, 2001

Sir:

Prior to examination, please amend the above-identified application as  
follows:

**IN THE SPECIFICATION:**

Page 1, below the title, insert the following:

## CROSS REFERENCE TO RELATED APPLICATIONS

This is the U.S. national phase application based upon international application no. PCT/IL00/00337 filed June 7, 2000, and published in English on December 14, 2000, which is a continuation in part of U.S. application serial no. 09/542,768 filed April 4, 2000. The entire disclosures of the prior applications are incorporated herein by reference.

## IN THE CLAIMS:

Amend claims 8 and 14 as follows:

8. (Amended) The method according to claim 1, wherein said IR-active gas species is carbon dioxide.
14. (Amended) The lamp according to claim 10, wherein said IR-active gas species is carbon dioxide.

## REMARKS

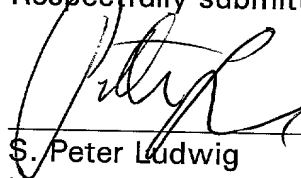
The specification has been amended to make reference to the prior applications.

Claims 8 and 14 have been amended to eliminate any multiple claim dependency. This is being done to reduce filing fees and not for any reason related to patentability of such claims.

A marked up version of the amendments pursuant to 37 CFR 1.121 is enclosed.

Entry of these amendments are respectfully requested.

Respectfully submitted,

A handwritten signature in black ink, appearing to read 'S. Peter Ludwig', is written over a horizontal line.

S. Peter Ludwig

Reg. No. 25,351

Attorney for Applicant(s)

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## INFRA-RED LIGHT SOURCE

### FIELD OF THE INVENTION

The present invention relates in general to the field of infra-red radiation sources, and in particular to sealed-off molecular gas discharge sources.

### BACKGROUND OF THE INVENTION

The technology underlying the operation and production of electrode-less cold gas discharge infra-red lamp sources has been described in U.S. Patent No. 5,300,859, entitled "IR-Radiation Source and Method for Producing Same" to S. Yatsiv et al., hereby incorporated by reference in its entirety. One of the important advantages of such lamp sources is that they emit very narrow spectral lines at discrete frequencies characteristic of the molecular rotational-vibrational to ground state transitions of the excited gas species contained in the lamp. This is achieved in a source which is sealed-off, is compact, has a good level of conversion efficiency from electrical to optical power, and has a long life compared with previously available sealed-off lamps sources.

Because of their unique spectral properties, such lamps have been widely used as sources in non dispersive infra-red (NDIR) spectrometry instruments, and especially in gas analyzers for use in medical applications. The narrowness of the emission lines provides such gas analyzers with high levels of selectivity, sensitivity and stability, which are many times better than gas analyzers of similar complexity, which use alternative technology sources, such as hot blackbody sources. The other advantages mentioned above enable the production of compact and cost effective instrumentation using such sources.

The lamp sources described in U.S. Patent No. 5,300,859 have found particularly advantageous applications as sources of the CO<sub>2</sub> spectral emission lines, for gas analysis of exhaled breath, to determine the levels of CO<sub>2</sub> therein. Such CO<sub>2</sub> sources have been used to great advantage in capnography and breath

testing instrumentation. Since the mechanisms and dynamics of the electrical excitation of CO<sub>2</sub> and of its ensuing spontaneous emission spectrum are similar to those used in carbon dioxide lasers, there exists a very large body of knowledge and prior art concerning this technology.

In U.S. Patent No. 5,300,859, there is a thorough discussion regarding the parameters affecting the lamp emission rise and decay time, efficiency, excitation and output, and the lamp lifetime as a function of chemical methods used to clean the lamp before sealing. On the other hand, the question of the spectral stability of the lamp source is not addressed. However, when used as a frequency selective source in NDIR spectroscopic applications, spectral stability may be even more important than the above parameters. Intensity changes over time can easily be monitored and corrected by using a reference path, since lamp intensity is a single valued quantity. On the other hand, spectral changes can not be easily monitored or corrected for, because there is virtually infinite information in a spectrum. Changes in the lamp spectrum cause changes in the absorption cell absorption characteristics. If these changes are not known, then it is impossible to accurately measure gas concentrations using such lamp sources.

There therefore exists a serious need for a method of maintaining a high level of spectral stability in electrode-less cold gas discharge infra-red lamp sources of the type described in U.S. Patent No. 5,300,859.

The disclosures of all publications mentioned in this section and in the other sections of the specification, are hereby incorporated by reference, each in its entirety.

## SUMMARY OF THE INVENTION

The present invention seeks to provide a new method of producing cold gas discharge infra-red lamp sources with improved spectral stability, especially those operating with a carbon dioxide fill.

The spectral stability of the lamp source is of particular importance for use in such applications as in the gas analyzer of breath test instrumentation, where

high resolution, sensitivity and selectivity are required to accurately determine the concentration of one isotopic species in the presence of another. Lack of good spectral stability may cause small changes occurring in the source spectrum to be erroneously interpreted as intensity changes resulting from changes in isotopic concentration. It is to be understood though, that such lamps may be used in any gas analyzer application to provide high resolution, sensitivity and selectivity.

A number of factors affect the spectral stability of the electrode-less cold gas discharge infra-red lamp source, of the type used in the breath test instrumentation according to the present invention. These factors include temperature, electrode position and time. The first two are factors of the operating conditions and geometry of the lamp, and if well understood, can be well controlled. The third factor mentioned, namely change over time, is much more problematic, since such changes are due to long term changes in the composition of the gas fill. It is thought that a major cause for long term changes in the lamp output and spectrum is the result of the gradual break down of the IR-active molecule in the discharge. In the case of the carbon dioxide lamp, the carbon dioxide dissociates into carbon monoxide and oxygen. In the course of the first few minutes of lamp operation, an equilibrium of the above molecules is reached, but over a longer period of operation, this equilibrium level changes as CO and O<sub>2</sub> are adsorbed on the walls of the lamp envelope. Impurities also reduce the CO<sub>2</sub> level still further.

Up to now, the majority of the prior art on the subject of the changes with time in the operating conditions of electric discharges in carbon dioxide has been primarily concerned with the change in power output which occurs as the CO<sub>2</sub> level changes. This has been the main point of interest because of the importance of avoiding a decay over time in the power levels of CO<sub>2</sub> lasers, and especially of sealed-off CO<sub>2</sub> lasers.

However, in the case of discharge lamps, whose emitted radiation is a result of non-coherent, spontaneous emission from an excited state to the ground state, changes in CO<sub>2</sub> concentration also affect the emission spectrum by means of a process known as self-absorption. In CO<sub>2</sub> lasers, on the other hand, this

phenomenon is, for all practical purposes, virtually non-existent. The phenomenon of self-absorption operates in the following way. The CO<sub>2</sub> molecules in the lamp not only emit radiation when excited, but they also absorb radiation when in the ground state, by means of induced absorption. The lamp itself thus operates as an absorption cell to its own emitted light as this light passes through the lamp's own gas fill to the output window. The CO<sub>2</sub> lines are absorbed at their centers, and their shapes thus change by means of the process known as self-absorption.

The effect of self absorption on NDIR spectroscopy measurements can be significant. Even when Doppler broadened, the lines emitted from the lamp are much narrower than the absorbing lines in a gas sample at atmospheric pressure. As a result, the region of coincidence on the absorbing lines is of approximately constant magnitude. Hence, although there is no change in absorption characteristics for any individual emission line for different degrees of self-absorption, the change in the distribution of the individual line intensities does cause an overall change in the absorption characteristics. As a result, changes in self-absorption create a change in the emitted line strength distribution of the first order band group, i.e. the weaker absorbing lines of the Boltzman distributed intensities traverse the lamp with little attenuation, even in the presence of the high CO<sub>2</sub> concentrations inside the lamp, but the strongly absorbing lines of the Boltzman distributed intensities are strongly attenuated.

These changes in line intensity distribution are similar in their effect on the absorption characteristics to changes in distribution resulting from changes in relative group/order (isotope) strength, or Boltzman distribution changes resulting from changes in temperature.

Expressed mathematically, the lamp output radiation after absorption in the gas cell is given by:

$$I = \sum e^{-\alpha_1 l_j d c} I_{1j} + \sum e^{-\alpha_2 l_j d c} I_{2j}$$

where  $I_1$  and  $I_2$  are for the first and second order respectively, and are defined over their line intensities  $I_{nj}$ . This relationship follows from the well-known Beer-Lambert law.

Defining a distribution ratio  $X = \sum I_{1j} / (\sum I_{1j} + \sum I_{2j})$ , which is the output ratio between first and second order of line distribution  $j$ , the transmission  $t_{(c)}$  is given by:

$$t_{(c)} = t_{1(c)} X + t_{2(c)} (1-X)$$

for any given concentration  $c$ .

When the lamp  $\text{CO}_2$  concentration changes with time, this distribution ratio changes and hence, also the absorption characteristics of the complete optical system, consisting of the emitting lamp together with the absorbing cell. Under these conditions, it becomes difficult to distinguish such changes from the changes in gas concentration being measured.

Although self-absorption can be anticipated from theory, it is difficult to demonstrate directly. This is mainly because the typical line width of the lamp is less than  $0.006\text{cm}^{-1}$ . The only instrument currently available which is capable of resolving such a narrow width is an FTIR (Fourier transform infra-red) spectrometer, with a mirror movement of at least 2 meters. The self absorption fine structure is even more difficult to resolve.

Experiments have been performed to observe the effect in discharge lamps, by using an FTIR spectrometer with possibly one of the optimum resolutions currently attainable. Comparisons between aged and new lamps for changes in line shape clearly show the effect. Other effects such as changes in Boltzman distribution, or changes in the ratio of first and second order lines, are shown to be negligible in comparison.

It is well-known in the art that one method of encouraging the recombination of dissociation products of molecules broken down under the effect of electrical discharges, to reproduce the parent gas molecule from which they originally dissociated, is by the use of catalysts. In the case of the  $\text{CO}_2$  discharge, the carbon monoxide and oxygen molecules within the lamp envelope can be recombined under the influence of suitable catalysts, to reform the  $\text{CO}_2$  molecules from which they dissociated. In sealed-off laser  $\text{CO}_2$  laser technology, such catalysts are widely used to maintain the level of  $\text{CO}_2$  in the laser cavity, in

order to prevent a decay in the laser power output which would occur if the percentage of dissociated CO<sub>2</sub> were to increase with time.

As mentioned above, the effect of self-absorption is effectively non-existent in CO<sub>2</sub> laser discharges, as also in other systems not lasing directly to the ground state. In the CO<sub>2</sub> laser, the stimulated emission of the laser light is produced by a decay transition from a metastable state down to a short-lived excited state. It is this transition which produces the familiar CO<sub>2</sub> 10.6μm wavelength radiation. Since the lasing transition is not to the ground state, the large population of ground state molecules do not absorb the lasing transition energy, and for this reason, self-absorption is effectively non-existent in such laser discharges.

In gas discharge lamps of the type disclosed in U.S. Patent No. 5,300,839, on the other hand, the IR radiation is created by spontaneous emission in the wavelength region of 4.3μm, by transition of the IR active molecules from rotational-vibrational excited states, directly to the ground state. No metastable states are involved in this transition scheme. Since a high proportion of the CO<sub>2</sub> molecules populate the ground level, the spontaneous radiation associated with the transition to this ground level is readily absorbed by these ground state molecules, by the process of induced absorption. This results in appreciable self-absorption of the radiation. In this respect, discharge lamps are significantly different from the stimulated emission of laser discharges operating in the same molecular system, in that they show a significant self absorption effect.

The previously known catalyst technology used in laser discharges is aimed exclusively at maintaining the laser gain, the laser efficiency and the power output level of the emission from the laser. To the best of the Applicants' knowledge, no mention has been made or suggested, that such catalysts be used to maintain the spectral stability of the discharge, since the mechanism of self-absorption by which this could be performed, is not applicable to lasers. Furthermore, to the best of the Applicants' knowledge, catalysts have never been used, or their use suggested for stabilizing the emission spectra of gas discharge lamps.

There is thus provided, in accordance with a preferred embodiment of the present invention, a method for increasing the spectral stability of cold gas discharge infra-red lamp sources, by the use of a catalyst to reduce the changes with time in the concentration of excited gas molecules in the lamp active in emitting to ground state levels, thereby resulting in a reduction in the changes in self-absorption.

In accordance with yet another preferred embodiment of the present invention, there is provided a method of constructing an improved, electrically excited, gas discharge lamp, whose output is characteristic of spontaneous emission of at least one IR-active gas species to a ground state, consisting of the steps of constructing a lamp envelope, cleaning the lamp envelope, and filling the envelope with a gas mixture consisting of the at least one IR-active gas species, the improvement being the additional step of including a catalytic material within the lamp envelope.

In accordance with a further preferred embodiment of the present invention, there is also provided a method of constructing an improved electrically excited gas discharge lamp, whose output is characteristic of spontaneous emission of at least one IR-active gas species to a ground state, consisting of the steps of constructing a lamp envelope, cleaning the lamp envelope, and filling the envelope with a gas mixture consisting of the at least one IR-active gas species, the improvement being the additional step of including a catalytic material within the lamp envelope, such that the volume of the lamp can be decreased.

There is even further provided in accordance with another preferred embodiment of the present invention, a method of constructing an improved electrically excited gas discharge lamp, whose output is characteristic of spontaneous emission of at least one IR-active gas species to a ground state, consisting of the steps of constructing a lamp envelope, cleaning the lamp envelope, and filling the envelope with a gas mixture consisting of the at least one IR-active gas species, the improvement being the additional step of including

a catalytic material within the lamp envelope, such that the IR-active gas concentration can be decreased.

There is also provided in accordance with another preferred embodiment of the present invention, an improved electrically excited gas discharge lamp, whose output is characteristic of spontaneous emission of at least one IR-active gas species to a ground state, comprising a lamp envelope containing a gas mixture consisting of the at least one IR-active gas species, and electrodes external to the envelope for exciting the at least one IR-active gas species, the improvement being a catalytic material located within the lamp envelope.

There is further provided in accordance with yet another preferred embodiment of the present invention, any of the methods described above, wherein the catalytic material is operative to increase the spectral stability of the lamp by reducing changes with time in the level of self-absorption in the gas mixture.

Furthermore, in accordance with yet another preferred embodiment of the present invention, there is provided a lamp as described above, wherein the catalyst is operative to increase the spectral stability of the lamp by reducing changes with time in the level of self-absorption in the gas mixture.

Furthermore, in accordance with yet another preferred embodiment of the present invention, there is provided a lamp as described above, wherein the IR-active gas species is carbon dioxide. The concentration of the carbon dioxide may be less than approximately 5%.

In accordance with still more preferred embodiments of the present invention, the catalytic material may be coated on an inside wall of the envelope, and may be gold, silver, rhodium, iridium, palladium, platinum or nickel.

There is provided in accordance with yet a further preferred embodiment of the present invention, any of the methods described above, wherein the lamp volume is less than approximately 6 milliliters.



## BRIEF DESCRIPTION OF THE DRAWINGS

The present invention will be understood and appreciated more fully from the following detailed description, taken in conjunction with the drawing in which:

Fig. 1 is a schematic drawing of an improved electrically-excited gas discharge lamp, constructed and operative according to a preferred embodiment of the present invention.

## DETAILED DESCRIPTIONS OF PREFERRED EMBODIMENTS

A number of catalysts are known for reproducing  $\text{CO}_2$  from  $\text{CO}$  and  $\text{O}_2$ , such as platinum with tin oxide, sputtered gold and silver coatings. The method of providing the catalytic coating on the interior of the discharge lamp envelope, in order to increase the lamp's spectral stability, depends on the material used for the catalyst. According to one preferred embodiment of the present invention, the method consists of sputtering the gold in a finely divided form onto the inside of the lamp envelope, such that it forms a non-conducting film, with a very high surface to volume ratio. Other metals such as Iridium, Rhodium, Palladium and Nickel can also be used as catalysts. Other methods of applying the catalyst besides sputtering may also be used, such as chemical or vapor deposition.

Reference is now made to Fig. 1, which is a schematic drawing of an improved electrically-excited cold-cathode gas discharge lamp 10, constructed and operative according to another preferred embodiment of the present invention. The basic elements of the lamp construction are similar to those disclosed in U.S. Patent No. 5,300,859. The envelope 12 of the lamp defines an internal volume 14 which contains a gaseous mixture 16 including one or more IR-active gaseous species. The gas is preferably excited by two electrodes 18, 20, disposed outside of the envelope, and supplied with RF-exciting power via a pair of cables 22. After being raised to an excited state, the IR-active gaseous species decays by means of a spontaneous emission directly to the ground state, and the

emitted radiation is output by means of an optically transparent window 24 at one end of the lamp envelope. According to this preferred embodiment of the present invention, on the inner wall of the lamp envelope is a layer of catalyst 26, operative to maintain a constant level of the dissociation products of the IR-active gaseous species, such that the self absorption of the emitted radiation is kept at a constant level, and spectral stability of the lamp output maintained, as explained in detail hereinabove.

The catalyst is chosen to ensure an equilibrium between the IR-active gaseous species and its dissociation products. In this respect, it should be noted that unlike prior art use of catalysts in lasers, where the catalyst is optimally operative to keep dissociation of the IR-active species to a minimum, in order to keep laser output power to a maximum, according to the present invention, the catalyst need only maintain a constant equilibrium level of the IR-active species in order to achieve its aim of maintaining constant self-absorption and hence constant spectral stability. The catalyst may be applied by any of the methods known in the art, by chemical, sputtered or vapor deposition, or by any other suitable means. The catalyst may be of any of the types mentioned hereinabove.

Since the catalyst reduces the breakdown of  $\text{CO}_2$ , it is possible to reduce the need for a large ballast volume of gas, and thus to produce a lamp of considerably reduced size. Such a lamp is advantageous for use in portable systems. Such a smaller lamp has a better surface to volume ratio with respect to the active media and the activated  $\text{O}_2$  molecules require a shorter path length to reach the coating, and hence have a higher probability of reaching the catalytic coating in the required activated state. In U.S. Patent No. 5,300,859, lamp volumes of the order of 60 ml. are disclosed. This volume was required to ensure an adequate reservoir volume to ensure long lamp life. If lamps of smaller volume were used, the increased effect of the absorption of dissociated carbon monoxide and oxygen on the increased surface of the walls in relation to the gas volume, would result in the lamp discharge decaying very rapidly. The use of a catalyst on the lamp walls, according to a further embodiment of the present invention, allows significantly smaller lamps to be constructed, without

negatively affecting their lifetime or spectral stability. It is possible to achieve lamp volumes of 6ml or less, which provide similar lifetimes to those of the prior art 60ml volume lamps, while maintaining the same level of spectral stability. This is of significant advantage for use in the breath tester, where two lamp sources are typically required, whose mutual stability is dependent on the maintenance of both of them under similar environmental conditions, something that is simpler to achieve with more compact lamps.

Since the catalyst reduces the breakdown of CO<sub>2</sub>, the use of a catalyst according to the present invention, makes it feasible to produce a lamp with a lower CO<sub>2</sub> pressure. In U.S. Patent No. 5,300,859, CO<sub>2</sub> percentages of the order of 10% are recommended for optimum output and lifetime considerations. According to preferred embodiments of the present invention, the use of a catalyst allows the operation of the lamp with lower CO<sub>2</sub> concentrations in the lamp gas mixture, down to 5%. This results in lower self-absorption effects, with consequent higher intensity central lines of the absorption spectrum, as explained hereinabove. This provides very deep absorption curves with a high extinction ratio in the gas analyzer measurement cell, permitting use of a shorter cell path and a more compact instrument without losing detection sensitivity or selectivity. This is of high importance when measuring the very low concentration levels of the minority isotopic component in a breath test.

It will be appreciated by persons skilled in the art that the present invention is not limited by what has been particularly shown and described hereinabove. Rather the scope of the present invention includes both combinations and subcombinations of various features described hereinabove as well as variations and modifications thereto which would occur to a person of skill in the art upon reading the above description and which are not in the prior art.

## CLAIMS

We claim:

1. A method of constructing an improved, electrically excited, gas discharge lamp, whose output is characteristic of spontaneous emission of at least one IR-active gas species to a ground state, comprising the steps of:

constructing a lamp envelope;

cleaning said lamp envelope; and

filling said envelope with a gas mixture comprising said at least one IR-active gas species;

the improvement being the additional step of including a catalytic material within said lamp envelope.

2. The method according to claim 1, wherein said catalytic material is operative to increase the spectral stability of said lamp by reducing changes with time in the level of self-absorption in said gas mixture.

3. The method according to claim 1 wherein said catalytic material is coated on an inside wall of said envelope.

4. The method according to claim 1, wherein said catalytic material is chosen from a group comprising gold, silver, rhodium, iridium, palladium, platinum and nickel.

5. A method of constructing an improved electrically excited gas discharge lamp, whose output is characteristic of spontaneous emission of at least one IR-active gas species to a ground state, comprising the steps of:

constructing a lamp envelope;

cleaning said lamp envelope; and

filling said envelope with a gas mixture comprising said at least one IR-active gas species;

the improvement being the additional step of including a catalytic material within said lamp envelope, such that the volume of said lamp can be decreased.

6. The method according to claim 5, wherein said lamp volume is less than approximately 6 milliliters.

7. A method of constructing an improved electrically excited gas discharge lamp, whose output is characteristic of spontaneous emission of at least one IR-active gas species to a ground state, comprising the steps of:

constructing a lamp envelope;

cleaning said lamp envelope; and

filling said envelope with a gas mixture comprising said at least one IR-active gas species;

the improvement being the additional step of including a catalytic material within said lamp envelope, such that the IR-active gas concentration can be decreased.

8. The method according to any of the previous claims wherein said IR-active gas species is carbon dioxide.

9. The method according to claim 8, wherein the concentration of said carbon dioxide is less than approximately 5%.

10. An improved electrically excited gas discharge lamp, whose output is characteristic of spontaneous emission of at least one IR-active gas species to a ground state, comprising:

a lamp envelope containing a gas mixture comprising said at least one IR-active gas species; and

electrodes external to said envelope for exciting said at least one IR-active gas species;

the improvement being a catalytic material located within said lamp envelope.

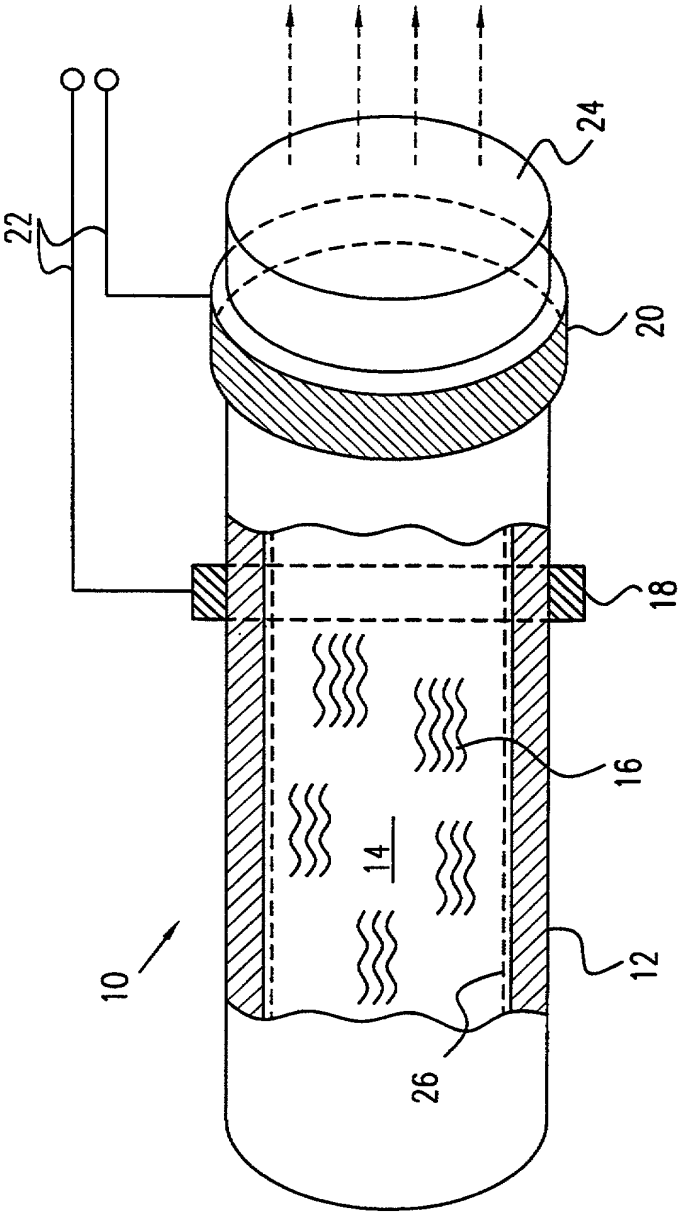
11. The lamp according to claim 10, wherein said catalyst is operative to increase the spectral stability of said lamp by reducing changes with time in the level of self-absorption in said gas mixture.

12. The lamp according to claim 10, wherein said catalytic material is coated on an inside wall of said envelope.

13. The lamp according to claim 10, wherein said catalytic material is chosen from a group comprising gold, silver, rhodium, iridium, palladium, platinum and nickel.

14. The lamp according to any of claims 10 to 13, wherein said IR-active gas species is carbon dioxide.

FIG. 1



## COMBINED DECLARATION FOR PATENT APPLICATION AND POWER OF ATTORNEY

(Includes Reference to PCT International Applications)

ATTORNEY DOCKET NUMBER  
6727/OK097

As a below named inventor, I hereby declare that:

My residence, post office address and citizenship are as stated below next to my name.

I believe I am the original, first and sole inventor (if only one name is listed below) or an original, first and joint inventor (if plural names are listed below) of the subject matter which is claimed for and which a patent is sought on the invention entitled:

## INFRA-RED LIGHT SOURCE

the specification of which (check only one item below):

☐ is attached hereto.☒ was filed as United States applicationSerial No. 10/009,845on December 7, 2001

and was amended

on \_\_\_\_\_ (if applicable).

☐ was filed as PCT international application

Number \_\_\_\_\_

on \_\_\_\_\_

and was amended under PCT Article 19

on \_\_\_\_\_ (if applicable).

I hereby state that I have reviewed and understand the contents of the above-identified specification, including the claims as amended by any amendment referred to above.

I acknowledge the duty to disclose information which is material to the examination of this application in accordance with Title 37, Code of Federal Regulations, §1.56(a).

I hereby claim foreign priority benefits under Title 35, United States Code, §119 of any foreign application(s) for patent or inventor's certificate or of any PCT international application(s) designating at least one country other than the United States of America listed below and have also identified below any foreign application(s) for patent or inventor's certificate or any PCT international application(s) designating at least one country other than the United States of America filed by me on the same subject matter having a filing date before that of the application(s) of which priority is claimed:

## PRIOR FOREIGN/PCT APPLICATION(S) AND ANY PRIORITY CLAIMS UNDER 35 U.S.C. 119:

COUNTRY (If PCT indicate PCT)	APPLICATION NUMBER	DATE OF FILING (day, month, year)	PRIORITY CLAIMED UNDER 35 U.S.C. 119
ISRAEL	130372	08 June, 1999	<input checked="" type="checkbox"/> YES <input type="checkbox"/> NO
			<input type="checkbox"/> YES <input type="checkbox"/> NO
			<input type="checkbox"/> YES <input type="checkbox"/> NO
			<input type="checkbox"/> YES <input type="checkbox"/> NO



US

Combined Declaration for Patent Application and Power of Attorney (Continued) (Includes Reference to PCT International Applications)				ATTY'S DOCKET NUMBER 6727/OK087	
<p>I hereby claim the benefit under Title 35, United States Code, §120 of any United States application(s) or PCT international application(s) designating the United States of America that is/are listed below and, insofar as the subject matter of each of the claims of this application is not disclosed in that/those prior application(s) in the manner provided by the first paragraph of Title 35, United States Code §112, I acknowledge the duty to disclose material information as defined in Title 37, Code of Federal Regulations, §1.56(a) which occurred between the filing date of the prior application(s) and the national or PCT international filing date of this application:</p>					
<p>PRIOR U.S. APPLICATIONS OR PCT INTERNATIONAL APPLICATIONS DESIGNATING THE U.S. FOR BENEFIT UNDER 35 U.S.C. 120:</p>					
U.S. APPLICATIONS			STATUS (Check one)		
U.S. APPLICATION NUMBER	U.S. FILING DATE	PATENTED	PENDING	ABANDONED	
09/542,768	04 April 2000		X		
PCT APPLICATIONS DESIGNATING THE U.S.					
PCT APPLICATION NO.	PCT FILING DATE	U.S. SERIAL NUMBER ASSIGNED (if any)			
PCT/IL00/00337	07 June 2000				
<p>POWER OF ATTORNEY: As a named inventor, I hereby appoint the following attorney(s) and/or agents to prosecute this application and transact all business in the Patent and Trademark Office connected therewith. Morris Nelson #15,108, Gordon D. Coplein #19,165, William F. Dudina, Jr. #20,589, Michael J. Sweedler #19,937, S. Peter Ludwig #25,351, Paul Fields #20,298, Joseph B. Lerch #26,938, Melvin C. Garner #26,272, Ethan Horwitz #27,646, Beverly B. Goodwin #28,417, Adda C. Gogoris #29,714, Martin E. Goldstein #20,869, Bert J. Lewen #19,407, Henry Sternberg #22,408, Peter C. Schechter #31,682, Robert Schaffer #31,194, Robert C. Sullivan, Jr. #30,499, and Joseph R. Robinson #33,448</p>					
Send Correspondence to:			Direct Telephone Calls to: (name and telephone number)		
<p>S. Peter Ludwig, Esq. DARBY &amp; DARBY P.C. 805 Third Avenue New York, New York 10022-7513</p>			<p>(212) 527-7700 S. Peter Ludwig, Esq.</p>		
2	FULL NAME OF INVENTOR	FAMILY NAME	FIRST GIVEN NAME	SECOND GIVEN NAME	
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2	POST OFFICE ADDRESS	POST OFFICE ADDRESS	CITY	STATE & ZIP CODE/COUNTRY	
2	FULL NAME OF INVENTOR	FAMILY NAME	FIRST GIVEN NAME	SECOND GIVEN NAME	
0	RESIDENCE & CITIZENSHIP	CITY	STATE OR FOREIGN COUNTRY	COUNTRY OF CITIZENSHIP	
3	POST OFFICE ADDRESS	POST OFFICE ADDRESS	CITY	STATE & ZIP CODE/COUNTRY	
<p>I hereby declare that all statements made herein of my own knowledge are true and that all statements made on information and belief are believed to be true; and further that these statements were made with the knowledge that willful false statements and the like so made are punishable by fine or imprisonment, or both, under section 1001 of Title 18 of the United States Code, and that such willful false statements may jeopardize the validity of the application or any patents issuing thereon.</p>					
SIGNATURE OF INVENTOR 2A		SIGNATURE OF INVENTOR 2B		SIGNATURE OF INVENTOR 2C	
DATE		DATE		DATE	
Mar. 13 2002					